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ASSESSMENT OF LAND USE/ COVER CHANGE IN THE PERIOD 2000 – 2015 AND FORECAST TO 2030 IN TRA VINH PROVINCE

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ABSTRACT

Land use/ cover change of Tra Vinh province has been adversely affected by climate change. Therefore, it is extremely necessary to have solutions to tackle this problem immediately and thoroughly. First and foremost, some measures should be taken which involve restructuring covering/ land use together with the restructuring of seed varieties and crop to ensure the effective and sustainable development. For an overview of these changes as well as forecasts for the following years, this study uses remote sensing especially Landsat changes in covering/ land use from 2000 to 2015, combined with Markov Chain mode to analyze the volatility overlay structure/ main land use in Tra Vinh province to 2030.

KEYWORDS: Land Use Change, Cover Change & Markov Chain

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Original Article

INTRODUCTION

Land use/ cover change is of global interest nowadays. Tra Vinh is a coastal province in the Mekong Delta area that has been seriously affected by climate change. Therefore, it is essential to study and evaluate the structural change in the cover/ land use in Tra Vinh province in the period 2000 - 2015 and forecast the changes for 2030. In this study, Markov Chain model will be used to assess and predict the fluctuations of the cover change/ land use.

MATERIALS AND METHODS

The Scope of the Study

The scope of the study is limited by the area of Tra Vinh province with the geographical location from 9°31'46" limit to10°04'05" north latitude and 105°57'16" to 106°36'04" east longitude.

RESEARCH METHODOLOGY

Data Using

In this study, the images from Landsat ETM+5 and 8 OLI in four stages in 2000, 2005, 2010 and 2015 with a resolution of 30 m and map data from the map data of land use in Tra Vinh province, the rate of 1 / 100,000, 2000 (Table 1); Data land use map in Tra Vinh province, the rate of 1/ 100,000, 2015; were used the classification and evaluation of test results the classification.

Table 1: Landsat Data Images Used for Classification

Sensor	Date	Resolution	On Stage
Landsat 5	21/06/1999	30 m	2000
Landsat 5	09/05/2001	30 m	
Landsat 8	18/09/2014	30 m	2015
Landsat 8	14/02/2017	30 m	

Research Methods

Methods of mapping and analysis of structural changes overlay/ main land use period 2000 - 2015: was established from two map overlays/ main land use in 2000 and 2015.

The GIS tools were used to analyze spatial data, standardizing and integrating numerical and map data into the database as well as data overlay. Matrix of volatile coatings/main land use period from 2000 to 2015 was used to analyze the statistics of volatility of coating / main land use period 2000-2015.

Markov Chain models were applied to forecast the volatility of the overlay structure / main land use. A two-layer map was included to construct the transition matrix. Accordingly, the model will review each type of coating / land use and the determination of pixel conversion of the type coating / land use time t (2015) to the type of coating / other land use in time t + 1 (2030) to calculate the number of pixels conversion and converted into a percentage change of each type of coating / land uses. Formula calculated as follows (Trinh Le Hung et al., 2017):

$$L_{(t+1)} = L_{(t)} * P_{ij} \quad (1)$$

$$P_{ij} = \begin{bmatrix} P_{11} & P_{12} & \dots & P_{1m} \\ P_{21} & P_{22} & \dots & P_{2m} \\ \dots & \dots & \dots & \dots \\ P_{m1} & P_{m2} & \dots & P_{mm} \end{bmatrix} \quad (2)$$

$0 \le P_{ij} \le 1$ và $\sum_{j=1}^{m} P_{ij} = 1$

And P_{ij} is the transition probability matrix of the coating/ use (i) to deposit / land use (j). The probability of transition state between each pair is recorded as a transition-probability matrix element. The assumption of stability in this matrix, with the passage of time, it can be used to predict the distribution of the class Land use/land cover in the future from the present data. This means that in the future, from 2015 to 2030, the process of coating/land change can occur similarly to the period of 2000 - 2015. In this study, the probability matrix is 10 x 10.

L (t): the area of plating time.

L (t + 1): the area of the coating time t + 1.

L (t) and L (t + 1) was also recorded as a matrix shape is 1x M, M is the number of the coating. In the study, the matrix of 1 x 10.

The input of Markov Chain analysis included two parameters which were the area of 10 land use overlay in 2015 and matrix switching probability between the coatings/land use from years 2000 to 2015. The area of 10 land use/overlay in 2015 was calculated directly after the process of classification of remote sensing images. Probability transition matrix between the coatings/land use was determined on the ArcGIS software after performing the process of pairing two husband map classification in 2000 and 2015.

This research used Markov models to forecast the land use/cover in Tra Vinh province. Forecasting land use/cover of the years 2000 and 2015 comply with rule jump time (time steps) was 15 years, the forecast dates were determined by the formula (1). By applying the formula above, the study identified the time of volatility covering/land use overlay in Tra Vinh province as follows:

L2030 L2015 * P = [2015.2000]

The process of calculating the matrix was implemented in the Matlab language.

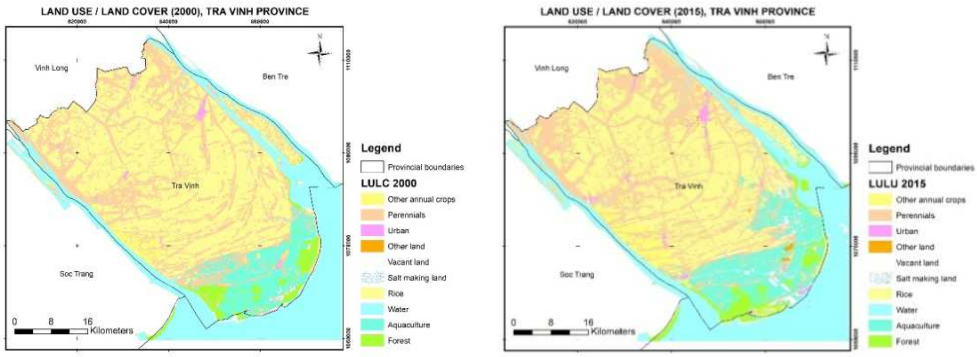
RESULTS AND DISCUSSIONS

Analyze, Evaluate Structural Changes Cover/ Main Land Use Period 2000 - 2015

Results Structure Land Cover/ Main Land Use in 2000 and 2015

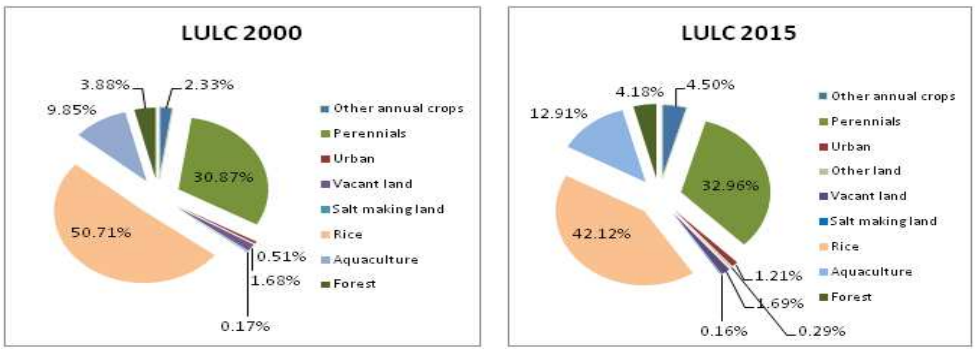
Results and statistical classification of an area covering/ land use in Tra Vinh province in 2000 (Figure 1a, 2a) showed that he area of rice cultivation and aquaculture seafood was nearly 51% and 10% respectively of the total land area of the province. The lowlands focused primarily in the areas of paddy land and groundwater aquaculture. Total rice area was 108.711 hectares classified in 2000, 2015 to 89.790 ha decline.

Statistical results and sorting area covering/ land use in Tra Vinh province in 2015 (Figure 1b, 2b) showed an area of wet rice cultivation dropped to 42% and the area of aquaculture increased to 13% of the total land area province. Perennial area increased from 31% to 33% from 2000 to 2015.



(a) **(b)**

Figure 1: Map Classification Land Cover / Main Land Use in 2000 (a) And 2015 in Tra Vinh (b)



(a) **(b)**

Figure 2: Structure of the Land Cover / Main Land use in 2000 (a), 2015 (b) in Tra Vinh

Results Assess Structural Changes of Land Use 2000 - 2015

The statistical results in Table 3 shows that the types of coating/land use experienced the most dramatic change including land areas for rice cultivation, fishery, perennial and annual plants. Thereby we see all kinds of coating area/land use change throughout the province in the period 2000 - 2015

Figure 2 shows the main land use/cover change in the period 2000 - 2015. In which, the land for rice cultivation declined significantly from 51% to 42% while the land for aquaculture increased from 10% to 13% and the land for perennial crops rose from 31% to 33%.

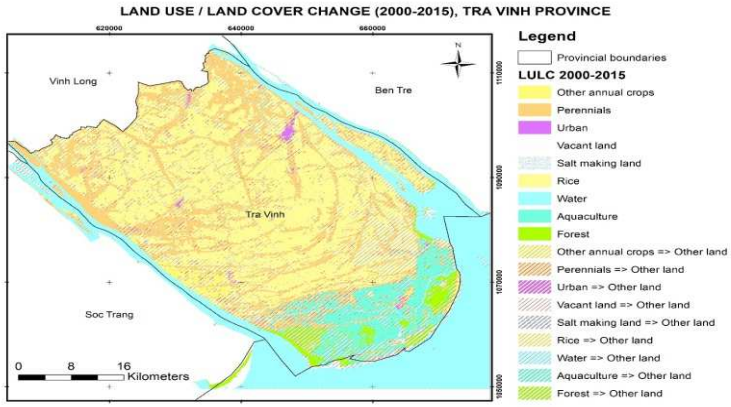


Figure 3: Map Change Land Cover/ Main Land Use Period 2000-2015

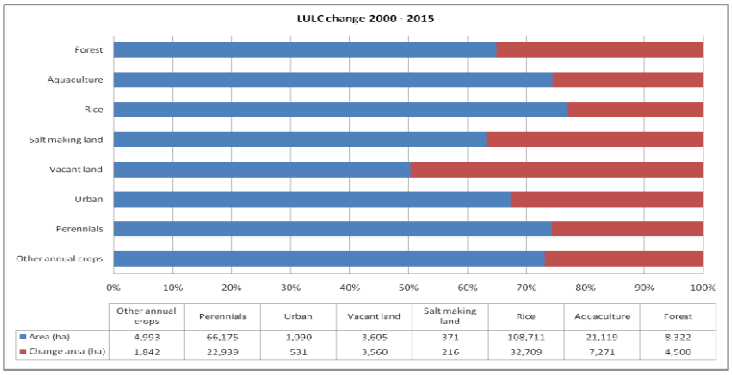


Figure 4: Comparison of the Area Varies Kinds of Cover/ Main Land Use in the 2000 - 2015

Table 1: The Results of Calculating the Amount of Change (Matrix Switch Area) Through Markov Chain Model for the Period between 2000 and 2015 Hectare Unit

2015											
2000	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Tổng**
1	***3,151***	1,245	52	47	11	0	266	36	103	74	***4,993***
2	2,940	***43,254***	1,089	239	502	32	11,843	1,077	355	4,825	***66,175***
3	14	329	***559***	27	16	0	42	25	57	18	***1,090***
4	0	0	0	***0***	0	0	0	0	0	0	***0***
5	337	600	88	3	***44***	0	1532	342	358	139	***3,605***
6	0	46	12	0	54	***155***	0	0	0	105	***371***
7	2,550	22,391	586	45	1,603	0	***76,007***	321	58	5,151	***108,711***
8	44	301	34	1	72	0	65	***69,448***	752	194	***71,491***
9	109	469	118	14	296	8	21	265	***3,834***	3,165	***8,322***
10	426	1,631	37	232	1,009	140	16	512	3,212	***1,3858***	***21,119***
Total	***9,594***	***70,417***	***2,577***	***608***	***3,609***	***335***	***89,809***	***72,979***	***9,308***	***27,539***	**485,717**

Aquaculture land increased gradually. From 2000 it was mainly converted from salt marshes and coastal paddy fields (Figure 2a). In addition, from 2000 to 2015, mangrove restoration increased by more than 500 hectares, intercropping with areas of Aquaculture and expanded to the sea. Especially the protected forest areas along the coast are restored, in order to protect the coast of Tra Vinh. Paddy land significantly declined from 2000 to 2015 and then mainly switched to residential land and land for aquaculture and other crops (Table 1).

Results Expected Volatility Structure Converting / Land Use in 2030

From the data about fluctuations covering/ land use between 2000 and 2015 and the current state of the coating/land use in 2015, the author forecast the distribution of land use/cover in 2030. The input of this process includes two parameters which are the area of the land use/cover at the present time (2015) and the transition probability matrix from a type of land use/cover to other type of land use/cover (transition probability of the overlays from 2000 to 2015). The output of this calculating process is the parameter of the area of land use/cover in the future (2030).

Accordingly, the Markov Chain was used to forecast the volatile distribution of covering/land use for the future and the projected changes were made as the formula (3). In which the parameters were as follows:

L2015 = [9.584 70.264 2.575 608 3.608 335 89.790 72.075 27.527 8.905] is the matrix area of the coating / main land use in 2015

L2030: the matrix area of the coating / main land use forecasts for 2030

P: is the calculated weight matrix transforms the area among between the object classes shown in table 2.

Table 2: Results Calculated Weight Matrix Switch Area Through Markov Chain Model for the Period 2000-2015

2015											
2000	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
1	0,63099	0,24927	0,01035	0,00935	0,00223	0,00000	0,05317	0,00719	0,02062	0,01483	1,00000
2	0,04442	0,65363	0,01646	0,00361	0,00759	0,00049	0,17896	0,01627	0,00537	0,07292	1,00000
3	0,01280	0,30234	0,51334	0,02511	0,01437	0,00000	0,03873	0,02337	0,05203	0,01693	1,00000
4	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000
5	0,09348	0,16653	0,02434	0,00085	0,01211	0,00010	0,42492	0,09475	0,09932	0,03852	1,00000
6	0,00000	0,12370	0,03153	0,00073	0,14431	0,41669	0,00000	0,00000	0,00000	0,28305	1,00000
7	0,02346	0,20596	0,00539	0,00042	0,01474	0,00000	0,69916	0,00295	0,00054	0,04738	1,00000
8	0,00062	0,00421	0,00047	0,00001	0,00101	0,00000	0,00091	0,97142	0,01051	0,00271	1,00000
9	0,01311	0,05635	0,01417	0,00168	0,03558	0,00096	0,00250	0,03180	0,46067	0,38030	1,00000
10	0,02017	0,07725	0,00173	0,01099	0,04777	0,00664	0,00076	0,02423	0,15211	0,65616	1,00000
Total	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**	**1,00000**

From the results above, we can see that, according to forecasts by the year 2030, the land area for annual trees is 12838 ha; perennial trees is 71.380 ha; the population is 4.207 ha; rice cultivation is 78.244 ha and aquaculture is 16.517 ha. Accordingly, the land area of rice cultivation has declined from 42% to 36% during 2015 - 2030 (Figure 5), corresponding to the hypothesis that the saltwater intrusion occurred in the period of 2000-2015 similar to the period of 2015-2030. Similarly, the structure of the aquaculture area is predicted to decrease from 13% to 12% in the period of 2015-2030. However, the area of impervious overlay - residential area tends to increase by 1% - 2% from 2015 to 2030. Therefore, if the process of urbanization continues to happen in the period 2015 to 2030 in the future, namely the year 2030, the residential area will be 4207 ha. The structure of forest area is expected to increase from 4% to 8% if the policy of reforestation and forest farming are carried out well in the period 2015-2030, the prediction of forest is estimated to reach 16.517 ha in 2030 (table 3).

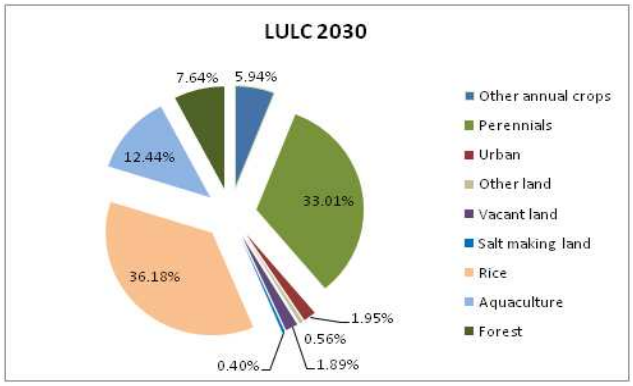


Figure 5: Land Cover Structure/Main Land UseForecasting the Year 2030 in Tra Vinh

Table 3: The Area of the Coating, the Main Land Use Forecasting the Year 2030 in Tra Vinh Province

Cover/ Main Land Use	2030 (Ha)
Cultivation of other annual crops	12,838
Cultivation of perennial trees	71,380
Uban	4,207
Other land	1,202
Vacant land	4,093
Salt production	868
Paddy land	78,244
Aquaculture	26,912
Forestry	16,517

CONCLUSIONS

The results of the initial study showed the potential of the use of Landsat data in monitoring a volatile area of the coating/land use at the provincial level. Research has established change map land cover/ main land use period 2000 - 2015. Also, the spatial statistical analysis methods of land use/cover change over time aided the observation and analysis of volatile area in the period 2000 - 2015 in Tra Vinh province.

In addition, the study also used Markov Chain models to forecast the volatility structure of the land cover/ main land use in Tra Vinh province for the period 2015 - 2030, based on the weight matrix change of land use from 2000 - 2015. The results showed that the structure of rice cultivation area is predicted to decline from 42% to 36% between 2015 and 2030, corresponding to the hypothesis that the salinization had taken place in the period 2000 - 2015 like the period of 2015 - 2030. However, the impervious overlay – residential area tends to increase by 1% - 2 from 2015 to 2030.

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